Medical Science

Red meat consumption and cardiovascular diseases in Al-Ahsa governorate, Saudi Arabia

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ABSTRACT

Background: Coronary artery disease (CAD) poses a major burden of diseases on Saudi Arabia. One of the potential dietary risk factors which are associated with the development of cardiovascular diseases is meat consumption. This study aimed to find the prevalence of CAD among meat consumers whether red or white meat and processed or unprocessed meat. *Method*: An observational cross-sectional study was conducted at the period from 5th November 2019 to 15th March 2020. A total of 220 people participated in the study conducted through a questionnaire distributed among Al-Ahsa residents. *Results*: The mean age of participants was 52.04 ± 7.56. The mean BMI was 28.32 ± 13.99. 126 (57.3%) of the participants were males and 94 (42.7%) were females. coronary artery disease (CAD) was present among 118 (53.6%) and absent in 102 (46.4%). The prevalence of CAD among unprocessed red meat consumers; n=76 (54.3%) was not found to be significantly different than that among white meat consumers; n=42 (52.5%). On the other hand, the prevalence of CAD was significantly different among participants among people who consume red meat at different frequencies. It was 50%, 44.4%, 78.9%in low, moderate, and high consumers respectively; P value 0.002. Moreover, significant CAD distribution was among processed meat consumers; n=35 (71.4%) versus unprocessed meat consumers; n=83 (48.5%). *Conclusion*: Consuming red meat at higher frequency and processed meat intakes were associated with higher prevalence of CAD.

Keywords: Red meat; White meat; cardiovascular diseases

1. INTRODUCTION

Cardiovascular diseases are leading causes of mortality and morbidity worldwide (Brown & Hazen, 2014; Bechthold et al., 2019; De Medeiros et al., 2019). In addition, cardiovascular diseases pose a major burden of disease on Saudi Arabia. According to World Health Organization, cardiovascular diseases account for 37% of the annual mortality rate in Saudi Arabia (World health organization, 2018). Smoking, excessive alcohol use, obesity, and sedentary lifestyle are responsible for 80% of population attributable risk factors of cardiovascular diseases (Bertoglia et al., 2010). In addition to these

risk factors, the dietary habits also can increase the risk of development of cardiovascular diseases (De Medeiros et al., 2019; Sala-Vila et al., 2015). Diet plays a significant role in increasing the risk of development of cardiovascular diseases (Sala-Vila et al., 2015). Diet can affect several biological pathways like energy expenditure, lipoprotein metabolism and blood pressure (Bronzato & Durante, 2017).

One of these potential dietary risk factors is meat consumption (De Medeiros et al., 2019; Wolk, 2017; Bergeron et al., 2019). Meat can be divided into two broad categories red and white (Escriba-Perez et al., 2017). The first category which is white meat includes chicken and turkey. The second category is red meat which can be further divided into two subdivisions processed and unprocessed. Processed red meat includes any meat that has gone under preservation methods including salting, curing and smoking. There are several examples of processed red meat which include hum, sausage and salami. Unprocessed red meat refers to all the types of mammalian muscles. There are several examples of unprocessed red meat like mutton, beef and camel (Bronzato & Durante, 2017; Wolk, 2017; Alisson-Silva et al., 2016; Connor et al., 2017).

The link between red meat and cardiovascular diseases is inconsistent (Connor et al., 2017; Sinha et al., 2009). Historically, the evidence optioned out of the epidemiological cohorts suggested that the consumption of red meat is associated with the risk of development of cardiovascular diseases (Connor et al., 2017). The consumption of red meat was linked with the risk of development of cardiovascular diseases based on the evidence which was accumulating since 1990 (Wolk, 2017; Alisson-Silva et al., 2016; Sinha et al., 2009). Several contributing factors had been proposed to be the reason behind this potential association. The first factor is the saturated fatty acids, as red meat contains a high quantity of saturated fatty acids (Brown & Hazen, 2014; Sala-Vila et al., 2015; Bronzato & Durante, 2017; Bergeron et al., 2019). The second factor is related to the metabolism of red meat. Red meat contains high amount of L-carnitine which is metabolized through several pathways in the body, at the end of its metabolism, Trimethylamine–N-oxide (TMAO) will be produced, and increased levels of trimethylamine N-oxide in the plasma are associated with an increased risk of development of cardiovascular diseases (Brown & Hazen, 2014; Alisson-Silva et al., 2016). A study has been conducted to assess the effects of fasting plasma TMAO on the risk of development of cardiovascular diseases in patient who have undergone coronary angiography, and the results suggested that an increased TMAO levels are associated with an increased risk of death, myocardial infarction and stroke over a period of three years (Wolk, 2017). Based on these two factors, the dietary recommendation stated that the intake of red meat should be limited. In addition, an advice was given to substitute the red meat by white meat which contains less amounts of saturated fat (Sala-Vila et al., 2015).

However, the potential association between red meat and cardiovascular diseases is being challenged currently (Mazidi et al., 2019). This association was shown based on a method of data collection that does not differentiate between processed and unprocessed red meat (Connor et al., 2017). Red meat was linked with cardiovascular diseases based on the findings of several studies (Mazidi et al., 2019; Son et al., 2019; Luan et al., 2020). However, this association was not shown upon the assessment of the association between unprocessed red meat and cardiovascular diseases (Thøgersen et al., 2020). Recent evidence from the epidemiological studies showed that the intake of red meat is neutrally or weakly associated with the risk of development of cardiovascular diseases (Sala-Vila et al., 2015).

A meta-analysis has been conducted to find out the effects of red meat intake on the risk factors of cardiovascular diseases. These risk factors included the blood lipids, lipoproteins, and blood pressure. The study hypothesis was that a daily red meat consumption exceeding half a serving would have a negative influence on these risk factors. However, the results of this study showed that a daily consumption exceeding half a serving of red meat had no negative impact on these risk factors. The largest category which was included under this study was consuming three servings of red meat daily with no negative impact on the risk factor for development of cardiovascular diseases reported at that category. Therefore, there was no visual threshold of total red meat consumption which indicates a negative impact on blood lipids, lipoproteins, and blood pressure (Connor et al., 2017).

The link between the intake of unprocessed red meat and cardiovascular diseases had been assessed through several studies (Brown & Hazen, 2014; Sala-Vila et al., 2015; Wolk, 2017; Alisson-Silva et al., 2016). However, there is lack of studies that have been conducted in order to find out the difference in the prevalence of coronary artery disease (CAD) among people consuming unprocessed red meat at different frequencies. Therefore, this study was conducted aiming to find the difference in the prevalence of CAD among unprocessed red meat consumers and white meat consumers. Also, this study aims to find if consuming unprocessed red meat was significantly associated with the prevalence of CAD; as well as finding if the prevalence of CAD significantly differs among people who consume unprocessed red meat at different frequencies.

2. METHOD

Study area and population

A cross-sectional study was conducted between 5th November 2019 and 15th March 2020. The population investigated in this study included residents in Al-Ahsa Governorate, Saudi Arabia. The study sample has been obtained through voluntary sampling method. The studied sample contained 220 participants. In order to be included at the study sample, the participant must fulfill two criteria: First, the participant's age must be above 40 years old; second, the participant must not be vegetarian or vegan.

Data collection

The data was collected using a questionnaire that was divided into three parts. The first part contained questions about the participant's demographical data. The second part contained questions that assess the frequency of at which the participants consume unprocessed red meat per week. The third part of the questionnaire contained questions that assess the past medical history of the participant focusing on the presence or absence of CAD based on already done coronary angiography or coronary CT angiography. In addition, this part contains questions concerning the participant's medical history of dyslipidemia, diabetes mellitus (DM) and hypertension (HTN).

Before distributing the questionnaire among the study sample, its reliability was assessed by distributing it among a pilot study sample containing 83 participants which were excluded from the study sample. After obtaining the data from these participants, the reliability of the questionnaire was accessed using Cronbach's alpha. After assessing the reliability of the questionnaire, its distribution has begun. The questionnaire was distributed in the form of hard copies. In addition, soft copies of the questionnaire were distributed simultaneously.

Data analysis

After collecting the data, it was analysed using Statistical Package for the Social Sciences (SPSS). Independent samples t-test was used to find out if the prevalence of CAD significantly differs among unprocessed red meat consumers and white meat consumers. Chi-squared test was used to find out if consuming unprocessed red meat was significantly associated with the prevalence of CAD. One-way ANOVA test was used to find out if the prevalence of CAD significantly differs among people who consume unprocessed red meat at different frequencies. It is stated that the daily unprocessed red meat consumption can range from 50-100g per parson (De Medeiros et al., 2019). Therefore, the participants were grouped into three groups on using one-way ANOVA: the first group consumed red meat at a frequency of less than two times per week; the second group consume red meat at a frequency of two to five times per week; the third group consume red meat at a frequency of more than five times per week. In addition, a post hoc test was used to find where the difference in the prevalence of CAD among the groups with different frequencies of unprocessed red meat consumption lies. Chi-squared test was used to find if consuming higher frequencies of unprocessed red meat was significantly associated with the prevalence of CAD, DM, HTN and dyslipidemia.

3. RESULTS

A total of 220 participants were enrolled in the study. Table 1 shows the sociodemographic characteristics of the participants. 126 (57.3%) of the participants were males and 94 (42.7%) were females. The mean age of the participants were 52.04 ± 7.56. The mean BMI was 28.32 ± 13.99. As for the place of residency, 154 (70%) were living in cities and 66 (30%) were living in villages. 9 (4.1%) had a primary school education, 7 (3.2%) had an intermediate school, 80 (36.4%) had a high school education, and 124 (56.40%) had a college education. Regarding employment, 15 (6.8%) were running their own business, 153 (69.5%) were employee, 18 (8.2%) were retired and 34 (15.5%) were out of work. Regarding exercise, 135 (61.4%) were exercising and 85 (38.6%) were not.

Table 1 Socio-demographic profile of the participant

Demographical Characteristics	n / mean	% / SD
Gender		
Male	126	57.3
Female	94	42.7
Age	52.04	7.56
BMI	28.32	13.99
Place of residency		
City	154	70.00

	Village	66	30.00
Education			
	Primary School	9	4.10
	Intermediate School	7	3.20
	High School	80	36.40
	University Education	124	56.40
Job			
	Running My Own Business	15	6.8
	Employee	153	69.5
	Retired	18	8.2
	Not Working	34	15.5
Do you exercise?			
	Yes	135	61.4
	No	85	38.6

Figure 1 shows the BMI categories of the participants. 4 (1.8%) were underweight, 76 (34.5%) had a normal weight, 81 (36.8%) were overweight, 27 (12.3%) had obesity class I, 19 (8.6%) had obesity class II, and 13 (5.9%) had obesity class III. Figure 2 displays the type of exercise practiced by participants who exercise. 87 (64.4%) were walking, 28 (20.7%) were playing football, 6 (4.4%) were weightlifting and 14 (10.4%) were practicing other exercises.
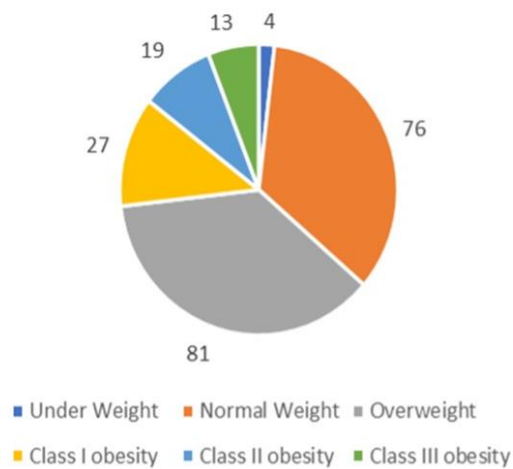

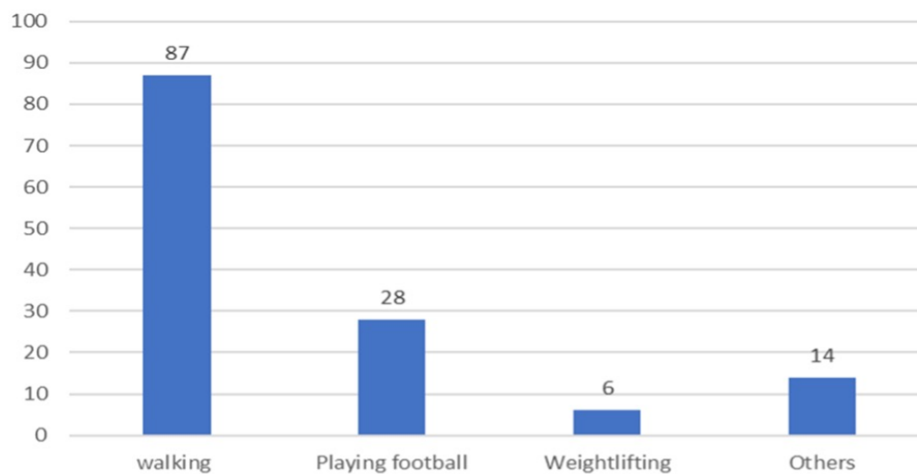**Figure 1** BMI categories of the participants

Figure 2 Type of exercise practiced by the participants who exercise

Figure 3 demonstrates the chronic diseases present in the participants. 50 (22.7%) had dyslipidemia, 31 (14.1%) had hypertension and 36 (16.4%) had diabetes. Figure 4 shows the prevalence of coronary artery disease among the participants. 118 (53.6%) had CAD and 102 (46.4%) did not.
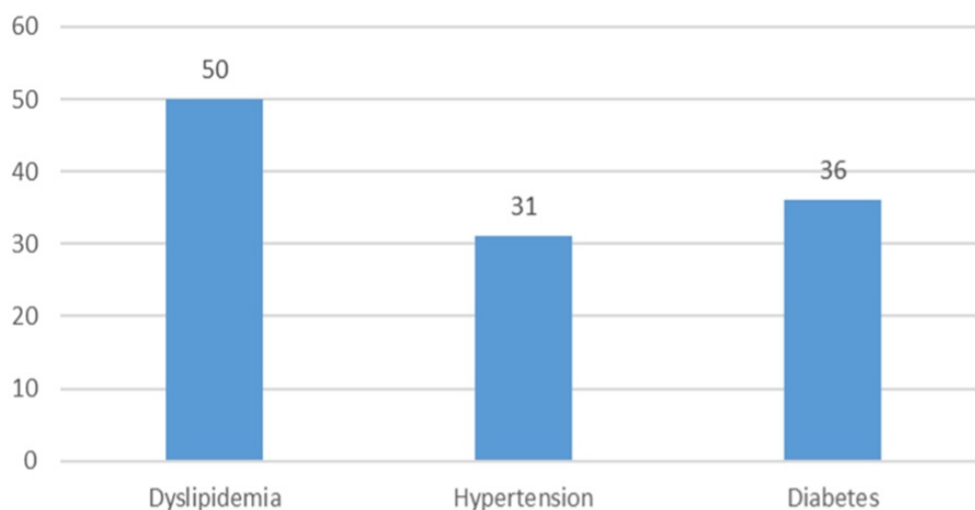

Figure 3 Presence of chronic diseases among the participants
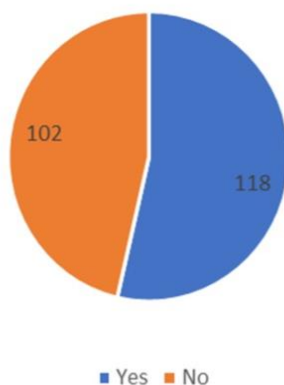

Figure 4 The prevalence of coronary artery disease among the participants

Table 2 displays the dietary habit and perception toward meat consumption among the participants. When asked what type of meat participants consume more, 140 (63.6%) consumed more unprocessed red meats and 80 (36.4%) consumed more white meat. The consumption level of unprocessed red meat was as following: 12 (8.6%) had a low consumption level, 90 (64.3%) had a moderate consumption level and 38 (27.1%) had a high consumption level. Among the participants, 119 (54.10%) stated they have a reason to reduce unprocessed red meat consumption. When asked about when did they start reducing their red meat consumption: 27 (12.3%) said before getting a heart disease, 12 (5.5%) said after getting a heart disease, 80 (36.4%) said they started on other times, and 101 (45.9%) said they did not reduce their red meat consumption. Regarding the method of reducing red meat consumption: 32 (14.5%) decreased their red meat consumption by having one day a week free of red meats, 20 (9.1%) decreased their red meat consumption by having only one meal with red meat in a day, 46 (20.9%) decreased their red meat consumption by reducing the size of the meat portion and 21 (9.5%) reduced their red meat consumption by other means and 101 (45.9%) did not decrease their red meat consumption. For processed red meat consumption, only 49 (22.3%) were consuming it. 98 (44.5%) of participants thought that cultural and financial factors in Saudi Arabia influenced their eating habits, while 122 (55.5%) did not.

Table 2 Participants dietary habits and perception toward meat consumption

Question	n	%
Q1/ Which type of meat do you eat more?		
Unprocessed Red Meat	140	63.6
White Meat	80	36.4
Q2/ Consumption of Unprocessed Red Meat Portions per Week Among Red Meat Dependents		
Low Consumption (1 Times a week)	12	8.6
Moderate Consumption (2-5 Times a week)	90	64.3
High Consumption (More than 6 Times a week)	38	27.1
Number of Red Meat Consumption (mean $\pm$ SD)	4.72 ± 2.43	
Q3/ Do you see any reason for which you should decrease your red meat consumption?		
Yes	119	54.10
No	101	45.90
Q4/ If you started reducing your red meat consumption, when was that?		
Before getting a heart disease	27	12.3
After getting a heart disease	12	5.5
Others	80	36.4
I did not decrease my red meat consumption	101	45.9
One day a week free of red meats	32	14.5
Q5/ The way that you are using to decrease your red meat consumption?		
Only one meal with red meat in a day	20	9.1
I reduced the size of the portion of meat I eat	46	20.9
Others	21	9.5
I did not decrease my red meat consumption	101	45.9

Cont.

Table 2 Participants dietary habits and perception toward meat consumption (Cont.)

	n	%
Q6/ Do you consume processed meat?		
Yes	49	22.30
No	171	77.70
Q7/Do you think cultural and financial factors in Saudi Arabia influences your dietary habits?		
Yes	98	44.50
No	122	55.50

Figure 5 demonstrates the reasons that made the participants think they should reduce their unprocessed red meat consumption. 72.3% said they think they should reduce red meat consumption because consuming too much red meat is harmful, 6.7% said because animal nourishment was unhealthy and 16.8% said due to their budget and 4.2% due to other reasons.
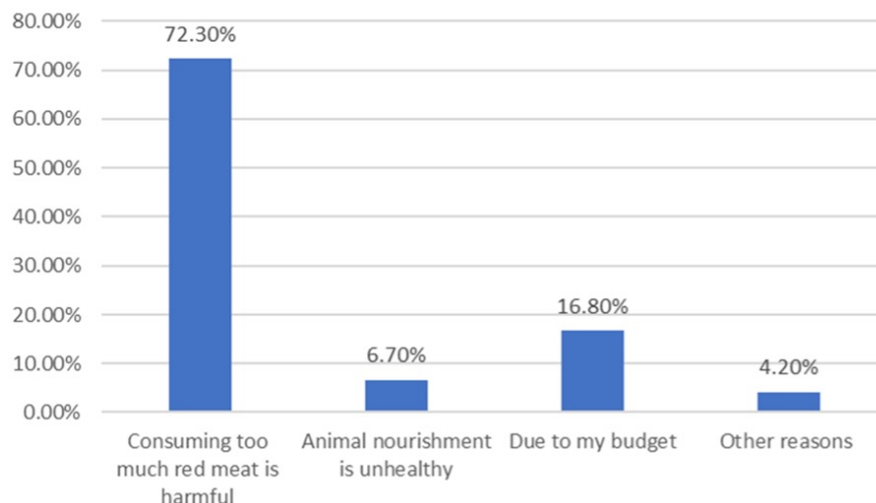
Figure 5 Reasons which made the participants think that they should reduce their red meat consumption

Table 3 shows the association between dietary habits and coronary artery disease. The most consumed type of meat was not significantly associated with the prevalence of CAD. However, the number of red meat portions consumed per week was found to be significantly associated with the prevalence of CAD. (p = 0.002), whereas higher rates of CAD were observed in participants who consume red meat at higher frequencies compared to those who consume it at low and moderate frequencies (78.9% compared to 50% and 44.4% respectively). The consumption of processed red meat was found to be significantly associated with the prevalence of CAD (p = 0.005) whereas a higher incidence of CAD was observed in those consumed processed meat compared to those who did not (71.4% vs 28.6%).

Table 3 The association between dietary habits and coronary artery disease

Factors	Have you ever suffered from CAD before?		P-value
	Yes	No	
Which type of meat do you eat more?			
Unprocessed Red Meat	76 (54.3%)	64 (45.7%)	0.798
White Meat	42 (52.5%)	38 (47.5%)	
Consumption of Red Meat Portions per Week			
Low Consumption (1 Times a week)	6 (50%)	6 (50%)	
Moderate Consumption (2-5 Times a week)	40 (44.4%)	50 (55.6%)	0.002*
High Consumption (More than 6 Times a week)	30 (78.9%)	8 (21.1%)	
Do you consume processed meat?			
Yes	35 (71.4%)	14 (28.6%)	
No	83 (48.5%)	88 (51.5%)	0.005*

* Significant at level 0.05

Table 4 displays the association between type of meat consumed the most with chronic diseases and BMI. The most consumed type of meat was not significantly associated with the risk factors of CAD (dyslipidemia, hypertension and diabetes). Table 5 demonstrates the relationship between number of red meat portion consumed per week with educational level and job. The number of portions of red meat consumed was not significantly associated with the educational level or job.

Table 4 The Association between Type of Meat Consumed More with Chronic Diseases and BMI

Factor	Which type of meat do you eat more?		P-value
	Unprocessed Red Meat	White Meat	
BMI (mean $\pm$ SD)	27.19 $\pm$ 6.32	30.29 $\pm$ 21.6	0.115
Dyslipidemia	32 (22.9%)	18 (22.5%)	0.952
Hypertension	21 (15%)	10 (12.5%)	0.608
Diabetes Miletus	25 (17.9%)	11 (13.8%)	0.428

* Significant at level 0.05

Table 5 The Association between Number of Red Meat Portion per Week with Educational Level and Job

Factors	Number of Unprocessed Red Meat Portions per Week		P-value
	Mean	SD	
Education			
Primary School	2.80	2.490	
Intermediate School	5.00	-	
High School	4.57	2.270	0.275
University Education	4.92	2.490	
Job			
Running My Own Business	4.11	2.710	
Employee	4.84	2.310	
Retired	5.17	2.620	0.604
Not Working	4.33	2.690	

* Significant at level 0.05

4. DISCUSSION

This study was conducted among male and female participants who live in Al-Ahsa governorate, Saudi Arabia. The prevalence of CAD among people who consume unprocessed red meat was not significantly different than that among white meat consumers. These results are consistent with the current evidence suggesting that the consuming unprocessed red meat is neutrally or weakly associated with the risk of CAD (Sala-Vila et al., 2015). These results are also consistent with a meta-analysis of three prospective cohorts with one case control study which suggested that consuming red meat was not significantly associated with the risk of CAD (Wolk, 2017). In addition, these results are consistent with the studies that suggested that a daily red meat consumption exceeding half a serving is not associated with a negative effect on the blood pressure and the lipid profile (Connor et al., 2017). On the other hand, these study findings are not consistent with some studies. Those include studies which suggested that consuming red meat is significantly associated with the prevalence of CAD (Connor et al., 2017; Thøgersen et al., 2020). These studies linked red meat with CAD due to its unsaturated fat contents. In addition, these studies suggested that trimethylamine N-oxide may play a rule at this association as well (Brown & Hazen, 2014; Alisson-Silva et al., 2016; Thøgersen et al., 2020).

The risk attributed to red meat was due to its contents of saturated fats (Bronzato & Durante, 2017). It was previously proved that red meat contains high amounts of saturated fat (Brown & Hazen, 2014; Sala-Vila et al., 2015; Bronzato & Durante, 2017; Bergeron et al., 2019). However, the association between the content of saturated fat lying within the red meat and cardiovascular diseases is inconsistent (Bronzato & Durante, 2017). Currently, consuming saturated fats is neutrally associated with the risk of cardiovascular diseases (Sala-Vila et al., 2015). In addition to its high saturated fat content, red meat contains L- carnitine which is a precursor of trimethylamine N-oxide. Higher plasma levels of trimethylamine N-oxide are correlated with the risk of cardiovascular disease. However, the concentrations of trimethylamine N-oxide after red meat intake can vary according to the background diet which is consumed with red meat. A high fat low fiber background diet is associated with higher concentrations of

trimethylamine N-oxide. On the other hand, high fiber low fat background diet is associated with lower concentrations of trimethylamine N- oxide. These finding were found in a study on a sample of pigs (Sinha et al., 2009; Yang et al., 2019).

Our study showed a significant association between the prevalence of CAD and consuming unprocessed red meat at higher frequencies. High and significant prevalence of CAD was observed among participants with high red meat consumers and significantly differ from those of low and moderate red meat consumers. These findings can be supported with the finding of a dose-response meta-analysis which suggested that the risk of development of CAD can increase with each extra 100 g of red meat added to the daily diet (Bechthold et al., 2019). In order to further address the issues of the link between red meat and the prevalence of CAD, further studies have to be conducted with inclusion of four additional variables. The first variable is the type of animal from which the red meat has been extracted because the saturated fat content of the red meat is different depending on the animal type from which the red meat has been extracted. This statement is supported by the findings of several studies. These studies suggested that fat makes up to 3.87% of mutton meat, 3% of beef meat and 2.1 to 2.77% of camel meat (Alisson-Silva et al., 2016; Williams, 2007; Shoman et al., 2019). The second variable is the daily consumed amount of red meat as findings of a meta-analysis suggested that red meat was significantly associated with CAD only among the Americans not Asian or European; also, it was suggested that the daily consumed amount of red meat might play a rule at the presence or absence of this association (Wang et al., 2016).

The finding of another meta-analysis suggested that a daily consumption of 150 grams of red meat is linked with 10-20% increase in the risk of development of CAD (Bechthold et al., 2019). The third variable is the way by which the red meat has been cooked as cooking modifies the chemical composition of meat through several biological reactions including lipid oxidation. Furthermore, the fat content of red meat is reduced by boiling more than grilling (Kamal et al., 2019). The fourth variable is fruits and vegetables consumption as they contain nutrients and phytochemicals that can neutralize the adverse effect of red meat (Thøgersen et al., 2020; Bellavia et al., 2016).

Limitations
The main limitation of this study is being a cross-sectional study which precluded determination of the cause behind the results which were found in this study. In addition, the absence of CAD among the participants was considered based on the past medical history told by the participants only without considering the potential findings indicating CAD on investigations that might have been undertaken by the participants or would be found if such investigations were taken.

5. CONCLUSION
Overall, a conclusion which could be reached is that this study supports the evidence that consuming red meat at higher frequencies, especially processed, is significantly associated with the increased risk of coronary artery disease. However, consuming red meat at lower quantity showed insignificant link to coronary artery disease.

Conflict of Interest
The authors declare that there are no conflicts of interest.

Ethical approval
The study was approved by the Medical Ethics Committee of King Faisal University (ethical approval code: 01\03\2019).

Data and materials availability
All data associated with this study are present in the paper.

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